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AN OVERVIEW OF

CLIMATE CHANGE AND BIODIVERSITY IN UGANDA

AUGUST 2014

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ARCC

African and Latin American
Resilience to Climate Change Project

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CLIMATE CHANGE AND BIODIVERSITY IN UGANDA

AFRICAN AND LATIN AMERICAN RESILIENCE TO CLIMATE CHANGE (ARCC)

AUGUST 2014

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ACRONYMS AND ABBREVIATIONS

BCFR	Budongo Central Forest Reserve
BINP	Bwindi Impenetrable National Park
DRC	Democratic Republic of the Congo
DWRM	Directorate of Water Resources Management
EBA	Ecosystem-based Adaptation
ECFR	Echuya Central Forest Reserve
FAO	Food and Agriculture Organization
ICF	International Children's Fund
IRG	International Resources Group
IUCN	International Union for Conservation of Nature
KNP	Kibale National Park
MFNP	Murchison Falls National Park
MGNP	Mgahinga Gorilla National Park
MWE	Ministry Of Water and Environment
NAPA	National Action Plan of Adaptation
NBI	Nile Basin Initiative
NEMA	National Environment Management Authority
NFA	National Forestry Authority
NGO	Nongovernmental Organization
PUBO	Pian-Upe-Opeta/Bisina
PUWR	Pian Upe Wildlife Reserve
QENP	Queen Elizabeth National Park
REDD	Reducing Emissions from Deforestation and Forest Degradation
RMNP	Rwenzori Mountains National Park
SNP	Semliki National Park
UN	United Nations
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
UWA	Uganda Wildlife Authority
WMD	Wetlands Management Department
WWF	World Wildlife Fund

1.0 INTRODUCTION

Biodiversity and ecosystem-specific goods and services in Uganda are likely to be adversely affected by climate change in the future. According to projections, Uganda will continue to experience rising temperatures, which will increase by more than 2 °C by 2030 (Tetra Tech ARD, 2013). Additionally, the growing variability of inter-annual rainfall is projected to continue, including increased rainfall during the dry season. These new climate scenarios are expected to increase the frequency of floods, droughts, and fires. This overview[1] provides an assessment of how biodiversity and ecosystem services are likely to be affected by climate change in the geographical regions of the Albertine Rift and Karamoja, as well as potential adaptation strategies for addressing these impacts.

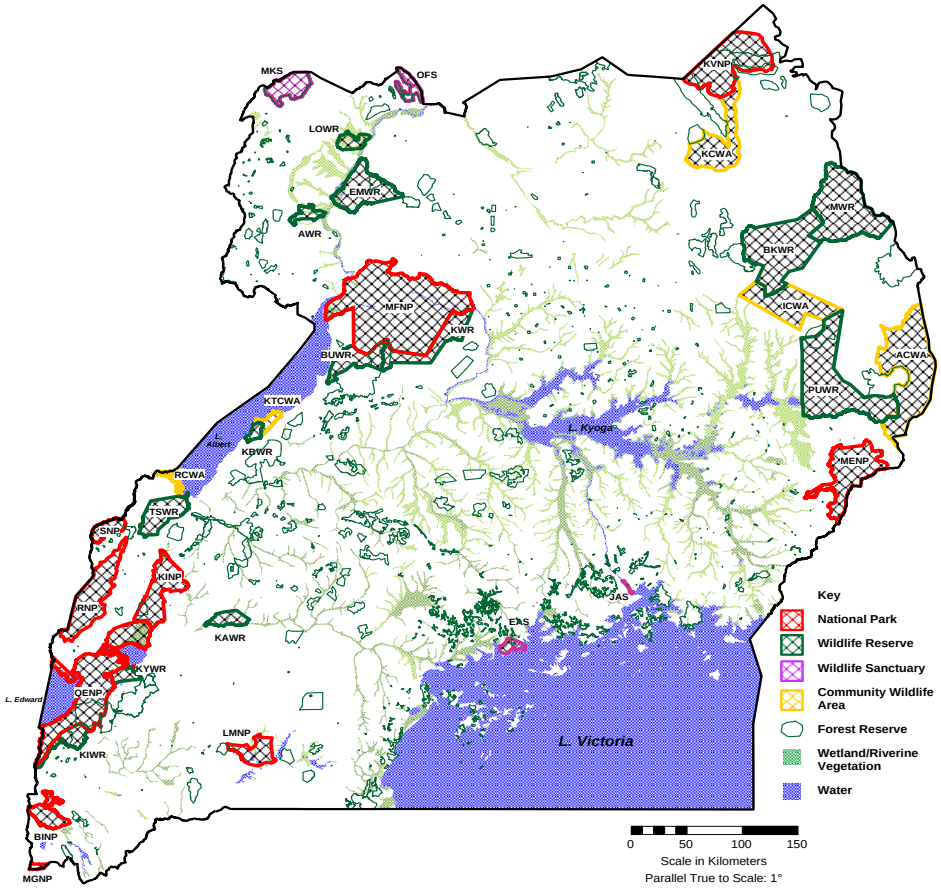
[1] This overview relies on secondary data from technical and scientific reports and publications, including the Uganda Climate Change Vulnerability Assessment undertaken by the United States Agency for International Development (USAID) and key informant interviews conducted by the author.

2.0 THE STATE OF BIODIVERSITY RESOURCES NATIONALLY

Uganda is rich in biodiversity because of its geographical location and altitudinal variation. Uganda has an altitudinal range of between 600 m above sea level (Nimule) to more than 5,000 m (Mt. Rwenzori). It is home to species of world-wide importance and contains a globally recognized biodiversity of species and habitats that are distributed throughout the country's vast wetlands, lakes, protected forests, and savannah grasslands.

There are six different bio-geographic regions: Uganda-Sudanian in the north, Somalia-Masai in the northeast, Guinea-Congolian in the west, Guineo-Congolian/Sudanian transition in the northwest, Afro-montane/Afro-alpine scattered in different mountains throughout the country, and the Lake Victoria regional mosaic (National Forestry Authority [NFA], 2012). Uganda is considered an international priority for conservation of endemic forest and aquatic species in Africa (Nile Basin Initiative [NBI], 2010).

MAP 1. LOCATION OF UGANDA'S PROTECTED WILDLIFE AREAS



Source: Uganda Wildlife Authority, 2010

Uganda's biodiversity resources are distributed across the country with high concentrations in protected areas (forests, savanna grasslands) and aquatic habitats (lakes, rivers, and wetlands). There are 720 protected areas representing approximately 30 percent of Uganda's land surface. These protected areas are for wildlife (10 National Parks, 12 Wildlife Reserves, and 12 Community Wildlife Areas) (Uganda Wildlife Authority [UWA], 2010; see Map 1) and protected forests (506 Central Forest Reserves, 192 Local Forest Reserves) (NFA, 2010; see Map 2). All the protected

areas are predominantly terrestrial, with minor lakeshore and wetland areas falling within land-based protected areas. As such, aquatic or wetland biodiversity is under-represented in the national protected areas system. Biodiversity outside protected areas is poorly documented but believed to be rich (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2012).

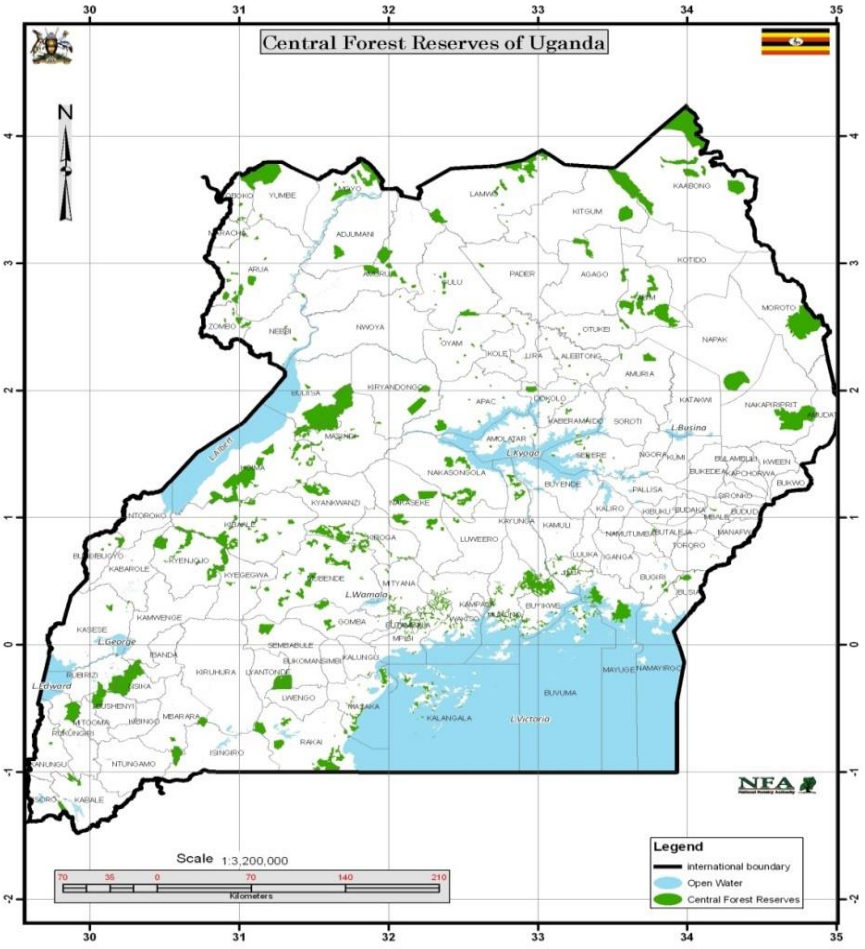
2.1 CLIMATE CHANGE & THE ALBERTINE RIFT & KARAMOJA REGIONS

The Albertine Rift and Karamoja region house most of the protected areas in Uganda and are the focus of this overview of climate change and biodiversity in Uganda. According to records from the UWA and NFA, the Albertine Rift contains seven of 10 national parks, more than 40 of 506 Central Forest Reserves and eight of 12 Wildlife Reserves. Karamoja houses one of seven National Parks, more than 13 of 506 Central Forest Reserves, and three of 12 Wildlife Reserves.

The Albertine Rift region also houses approximately 5,793 plant species, representing 14 percent of all mainland Africa's plant species. Of these species, 551 are endemic, and 25 are threatened (Plumptre et al., 2003). Dry montane forests and savannah grasslands in the Karamoja region contain rare and restricted-range species not found in other parts of Uganda (UNESCO, 2012).

Within the Albertine Rift and Karamoja regions, there are 12 biodiverse locations that are very likely to be adversely affected by climate change. The 12 locations identified by this assessment include: Mgahinga Gorilla National Park, Echuya Central Forest Reserve (ECFR), Bwindi Impenetrable National Park, Mt. Rwenzori National Park, Queen Elizabeth National Park, Kibale National Park, Semuliki National Park, Budongo Forest Reserve, Murchison Falls National Park, Kidepo National Park, Mt. Kei Forest Reserve, and Pian-Upe-Bisina-Opeta Wetlands complex. Table 1 presents the characteristics of each location and ecosystem goods and services and Annex 1 provides detail on location selection criteria.

MAP 2. CENTRAL FOREST RESERVES OF UGANDA



Source: National Forestry Authority, 2012

The identification of each of these locations takes into consideration: i) biodiversity species richness (levels of biodiversity endemism); ii) vulnerable groups represented, including keystone species such as the endangered mountain gorillas living in Mgahinga

Gorilla National Park and Bwindi Impenetrable National Park, as well as the presence of indigenous people whose livelihoods highly depend on resources from within these locations, such as Pygmies in Semuliki, Bwindi, and Mgahinga National Parks and Echuya Central Forest Reserve, and Ike in Mt. Kei Forest Reserve; iii) the likely effect of shifts in rainfall intensity, distribution, and reliability as well as changes in the severity and duration of dry season (e.g., maintained snow cover on Mt. Rwenzori and unreliable precipitation in savannah grasslands and wetlands); and iv) areas in which non-climate stressors (e.g., oil exploration and production in Albertine Rift ecosystems and expansion of agricultural production into protected areas) are already putting pressure on biodiversity and ecosystems or are likely to do so in the future.

TABLE 1. LOCATIONS LIKELY TO BE AFFECTED BY CLIMATE CHANGE
Mgahinga Gorilla National Park is an Afro-montane forest covering 4,750 ha (of which approximately 3,000 ha is forest) at an altitude range between 2,280 m and 4,127 m. Mgahinga borders Parc de Volcanoes and Virunga national park on Rwanda and the Democratic Republic of the Congo (DRC) portions of the Great Virunga Volcanoes. The park is home to mountain gorillas and 185 bird species. The key ecosystem goods and services are watershed values, tourism, and bamboo.
Echuya Forest Reserve encompasses 4,000 ha and includes a permanent high altitude swamp, Muchuya, which stands at 2,300 m in a narrow valley that is surrounded by steep forested hillsides. It is positioned at 01°17'S, 29°49'E. Echuya is particularly known for its high quality bamboo, *Yushania alpina*. There are also areas of broad-leaf forest, particularly along the eastern side and higher altitude northern end of the Kabale-Kisoro road. The forest cover is approximately 80 percent mature *Macaranga kilimandscharica* and *Hagenia abyssinica* forest and 20 percent mountain bamboo (*Yushania alpina)*. The forest contains the large alpine wetland Muchuya Swamp, which runs north-south along the reserve and drains to the southern boundary. Echuya Forest has high species diversity. Records show that the forest houses approximately 152 bird species, 54 butterflies, 43 moths, and 127 trees and shrubs, of which some enjoy global recognition as endangered species (e.g., Grauer's Swamp-warbler) or are near threatened (e.g., Kivu Ground Thrush, Handsome Francolin, and Red–throated Alethe). Approximately 40 percent of the butterflies are regional endemics. The key ecosystem goods and services are watershed values, tourism, and bamboo and indigenous people (Batwa).
Bwindi Impenetrable National Park is a large primeval forest covering an area of 327,000 ha with altitudes spanning from 1,160 m to 2,607 m above sea level. It is recognized as a World Heritage Site for being the home of half the world's population of endangered mountain gorillas as well as being one of the most biologically diverse areas on earth. It is home to 120 species of mammals, 346 bird species, 310 butterfly species, 163 tree species, 104 fern species, and 27 frog species, as well as other many endangered species. Key ecosystem goods and services include water catchment protection, tourism, and medicinal and cultural values; it is also home to a population of indigenous forest Pygmies (Batwa).
Rwenzori Mountains National Park covers 55,000 ha. It stands at an altitude of 1,700 m to 5,110 m and is a protected national park. The park hosts 217 bird species; contains 17 restricted range species; and has some rare and spectacular bird species, 21 mammals, 14 butterflies, 199 trees/plants, 24 Amphibians, and 100 species of fern. Key ecosystem goods and services include water catchment protection, tourism, and cultural values.
Queen Elizabeth National Park is a largely savanna covering 223,000 ha, of which approximately 40,000 ha is forest at an altitude ranging from 910 m to 1,365 m. The national park also overlaps with Maramagambo Central Forest Reserve and the Lake George Ramsar Site. The park is a Man and Biosphere Reserve with a unique combination of grasslands, woodlands, moist tropical forests, wetlands, and open water bodies/lakes. The park houses 610 bird species, 97 mammals, 288 trees/plants, and 54

reptiles. The key ecosystem goods and services include water, fisheries, and tourism.
Kibale Forest/Kibale National Park covers 560,000 ha, with the highest diversity and density of primates in Africa (totaling 13 species), 60 mammal species, 339 species of birds, 229 tree species, and 250 butterflies. Kibale forest is close to a site of Pleistocene refugium[2] and serves as the eastern limit of Congolean species. Key ecosystem goods and services include water catchment protection, tourism, and medicinal and cultural values.
Semliki National Park covers 21,900 ha (of which approximately 19,500 ha is forest) at an altitude ranging between 670 m and 760 m. The entire national park lies in the Albertine Rift bordering Virunga National Park in the DRC and North Rwenzori Forest Reserve in Uganda. The forest is cut off from the rest of East Africa by the Rwenzori mountains and represents an easterly extension of the great Ituri forests. Its flora and fauna show strong affinity with the Congo basin forests. The forest houses 131 of the 144 Guinea-Congo forest biome species (including 31 of the 70 species that are only found in Semliki), eight species of diurnal primates, and 51 species of butterflies. The main ecosystem goods and services are water, tourism, and provision of home to indigenous forest dwellers (the Batwa).
Budongo Forest Reserve covers 79,300 ha, lies at 31°35'E, 01°45'N, and is located in Masindi district. It stands at an altitude of 700 m to 1,270 m. It is a protected area and one of the important bird areas in Uganda. Two species of birds (Yellow-footed Flycatcher, Puvel's illadopsis) found in Budongo are not found anywhere else in East Africa. It is the second most important forest for the Guinea-Congo species after Semliki and hosts many other rare species. Conservation issues affecting the reserve and posing future threats to the birds include illegal pit sawing, poaching, and commercial sugar farming. Key ecological serves and goods include watershed values, timber, and tourism.
Murchison Fall National Park houses a combination of grasslands, wooded savannah, tropical forests, wetlands, and open water covering approximately 39,000 ha at an altitude of more than 600 m. The park houses 109 species of mammals, 476 bird species, and 145 trees/plants. The key ecosystem services are water, tourism, and cultural values.
Kidepo Valley National Park is a semi-arid plain interspersed with hills, rocky outcrops, and mountain ranges covering 144,200 ha (of which 2,000 ha is forest) at an altitude ranging between 1,220 m and 2,750 m. The park houses 472 species of birds; 86 species of mammals, of which 28 (including Cheetah) are not found in any other parks in Uganda; 192 trees; and 465 bird species. Ecosystem goods and services include watershed values, tourism, and traditional grazing ground for the pastoralist Karamajong people.
The "**Pian-Upe-Bisina-Opeta"** wetlands complex in Northeastern Uganda is an extensive flat grassland, floodplain grassland, and swamp system, which drains Mount Elgon and South Karamoja into Lake Kyoga. Lake Opeta is 56,600 ha; lies at 34°10'E, 01°40'N; and is shared by Katakwi, Kumi, Mbale, and Soroti districts. It stands at an altitude of 1,030 m and is an unprotected area. Lake Opeta and its surrounding swamp is the only significant wetland in the Karamoja area. It is one of the remaining few intact marshes in Uganda and the only permanent wetland in the Karamoja area. The area is important for pastoralism (it hosts up to 20,000 head of cattle in dry season). Lake Bisina is 6,100 ha and lies at 33°51'E, 1°42'N in Kumi district. It stands at an altitude of 1,030 m and is an unprotected area. The Fox's Weaver — the only endemic bird species in Uganda — is found in this area and appears to be common in the vicinity of water during the breeding season. The status of the species is not well established, but its distribution seems to be restricted to the northern part of the country. Seven Lake Victoria biome species are

[2] A favorable area where species have survived periods of glaciation during the Pleistocene Era.

recorded, including the papyrus Gonolek and the Northern Brown-throated Weaver, which breeds in the short fringing papyrus. Key ecological goods and services include provision of freshwater of good quality and quantity into international waters (through Lake Kyoga into the Nile System), seasonal grazing, fisheries, and cropland.

Mt Kei Forest Reserve is classified into dry combretum-Terminalia-Laudentia savanna and Brtyrospermum savanna woodlands at an altitude range of 915 m to 1,330 m above sea level between 31°10'E; 03°45'N. Mt Kei is important for housing a large number of species with limited distribution in Uganda. The Reserve houses 175 bird species and 30 uncommon plant species, three of them known in Uganda from this reserve only. A shrew, *Crocidura samalica*, is known from no other location in Uganda. The reserve also houses 180 species of butterflies and moth. The key ecosystem good and service is water shed protection.

The impact of climate change is likely to vary considerably across these diverse regions due to differences in their ecological complexity and locations.

2.2 CLIMATE CHANGE & POTENTIAL IMPACTS ON BIODIVERSITY

An increase in temperature or changes in rainfall intensity, distribution, and patterns are likely to have a direct effect on ecosystem functions, services, and species distribution and survival throughout Uganda. Projected climate change is likely to adversely affect the hydrological cycle of forested water catchments by weakening their capacity to maintain water cycles and recharge groundwater. This impact is likely to lead to a significant shift in flora and fauna distribution, disturb the ecological balance between species, cause habitat degradation due to increased prevalence of invasive species, and increase the occurrence of wild fires. As a result, the overall availability of ecosystem-specific goods and services that support human livelihoods is expected to be adversely affected.

Stress from climate change is likely to affect Uganda's biodiversity and ecosystem services in the following ways:

1. **A continued increase in temperatures may affect the hydrological cycle of forested water catchments through weakened water recharge or retention capacity.** A good example is Mt. Rwenzori, where snow cover has decreased by 40 percent between 1995 and 2011due to an increase in temperatures (International Resources Group [IRG], 2011). This reduction in snow cover has led to reduced year-round water flow in the rivers and streams draining from the mountain. This phenomenon will affect biodiversity (e.g., aquatic biodiversity) and human activities that depend on water in the Rwenzori hydrological system, both upstream (e.g., hydropower generation along the Mubuku River) and downstream (e.g., fisheries, livestock, and water-based tourism activities). Mt. Rwenzori also has a climate-driven altitudinal zonation of montane forest that is highly sensitive to temperature and precipitation. Mt. Rwenzori is perhaps the most climate change sensitive ecosystem in Uganda.

2. **Projected increases in temperatures will continue to trigger changes in flora and fauna**. As the climate warms, the various Afro-alpine vegetation zones shift progressively to higher altitudes, which are cooler. This shift will result in a decline in size of such afro-alpine vegetation zones (Pomeroy & Tushabe, 2004), would inevitably stress associated flora and fauna, and is likely to result in a loss of Afro-alpine biodiversity. This upward shift in Afro-alpine vegetation zones is likely to take place in most altitudes of more than 2,500 m above sea level.

   Forest ecosystems tend to exhibit lower sensitivity to increasing temperatures in comparison to grassland and aquatic ecosystems (ICF, 2009). This tendency is attributed to their high biodiversity and the complex relationships of species within the forest physical environment. In contrast, aquatic

ecosystems and aquatic biodiversity tend to be very sensitive to the effects of decreasing water flow and quality, which can have a severe and immediate impacts on aquatic biodiversity (ICF, 2009).

3. **Shifting flora and fauna are likely to lead to decreased availability of ecosystem resources that provide livelihoods for people**. Plant resources such as *Smilax anceps (enshuli)* from Bwindi National Park are extensively used for craft making and likely to be adversely affected by climate change. A shift in bamboo cover and bamboo die-back in Echuya Forest in southwestern Uganda has been reported to be linked to an increase in temperature and lower water table (Obed Tugumisirize, personal communication). Similar scenarios, though not yet documented, could occur in Mt. Rwenzori and Mgahinga, where Afro-alpine vegetation zones and bamboo are both present.

4. **Increases in temperature will create ecological conditions that favor colonization by invasive species**. It is highly likely that *Lantana camara*is — an invasive species that displaces pastures in grassland wildlife areas and is resilient to dry conditions — will expand its range under future climate scenarios; it is already a significant problem in Queen Elizabeth National Park. There is also speculation that increased colonization of congress weed (*Parthenium hysterophorus*) in Queen Elizabeth National Park is linked to dryer soil conditions due to increases in temperatures and a lowered water table (Justine Namara, personal communication).

5. **Increases in temperature will create conditions that trigger human-wildlife conflicts.** Extreme dry or wet conditions may trigger wildlife migration outside home ranges or entry of people and livestock into protected areas. Incidences of human and wildlife conflicts tend to increase during the dry season around Bwindi and Mgahinga National Parks, because the Mountain Gorillas extend their foraging range outside these protected areas (personal observation). Around savanna grasslands (e.g., Queen Elizabeth and Murchison Falls National Parks), human and wildlife conflicts tend to increase during the dry season due to the migration of cattle into the park in search of water and pasture.

6. **An increased temperature renders natural ecosystems vulnerable to disasters such as forest fires and more susceptible to pest and disease outbreaks.** The prevalence of pests, diseases, and mold tends to increase under wetter conditions and is likely to lead to increased post-harvest losses of forest products (Tetra Tech ARD, 2013). Due to continued high inter-annual variability, warmer temperatures combined with erratic precipitation substantially increase the likelihood of diseases and pests because both multiply more quickly under warmer conditions and are able to migrate to higher altitudes where their presence was previously unknown. Increasing temperatures could lead to dryer conditions and more frequent and destructive fire outbreaks.

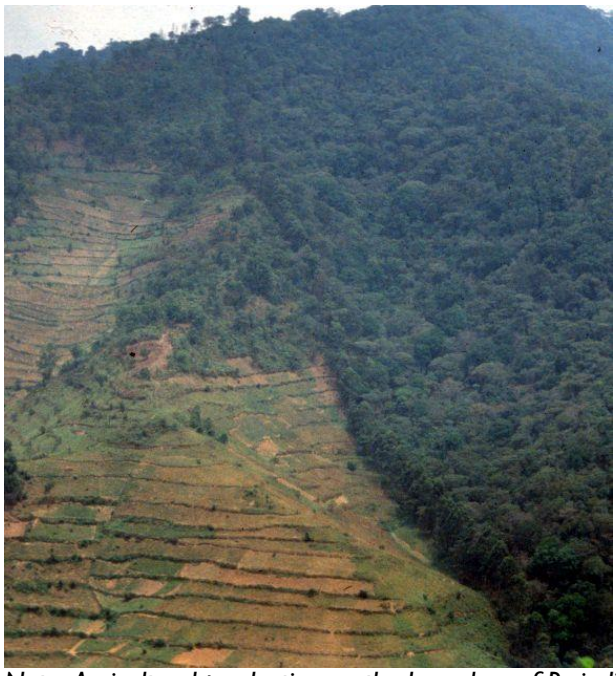
7. **Increasing frequency of severe floods due to high rainfall intensity is likely to cause social and economic hardship.** Floods result in displacement of people and their livelihoods (e.g., agriculture) particularly in low-lying areas such as the Pian-Upe-Bisina-Opeta Wetlands that are important for seasonal grazing, fisheries, and agriculture. On the other hand, low surface and ground water levels are already adversely affecting livelihoods. When the water level of Lake Victoria declined significantly in 2003-2006 due to a reduction of in-flows and precipitation over the lake, water transport and tourism activities at several beaches declined significantly (Directorate of Water Resources Management [DWRM], 2013).

An ecosystem's ability to adapt to external influences such as climate change is linked to its biodiversity richness, altitude, geological formations, and physical environment within and adjacent to the particular ecosystem. Biodiversity richness supports complex interaction among flora and fauna and their physical environment. Tropical ecosystems in Uganda have a high capacity to adapt because of high biodiversity richness (ICF, 2009); therefore, the richer the diversity of species and habitats (e.g., tropical forests), the greater the likelihood that the ecosystem will withstand a higher range of climatic variations.

The effects of increased temperature and short dry periods tend to be easily observed at the ecosystem level because of physical changes in the landscape (e.g., shrinking snow cover on Mt. Rwenzori or increases in tree die-back in Echuya Central Forest Reserve). These effects are less noticeable at the individual species level, where the impact of climate change may not be easy to detect, because individual species adapt to these changes to some extent (e.g., through local migrations of large herbivorous mammals from dryer to wet areas during the dry periods) until such adaptation is no longer possible. However, impacts at the species level could accumulate at higher levels because of interdependent relationships between different species through the food chain and inter-species competition processes (ICF, 2009).

Among species, there are different behavioral and physiological capacities to withstand climate change effects. As discussed above, terrestrial species tend to have higher capacity to withstand or adapt to climate change effects because they are able to migrate (e.g., birds, large mammals) or to adapt their feeding and breeding behavior. For example, the lesser flamingos in Queen Elizabeth National Park move (local migration) from Lake Munyanyange during the dry season (January-February) to Bagusa Crater Lake in Kyambura George and return to Lake Munyanyange during the wet season.

IMAGE 1. BOUNDARY OF BWINDI IMPENETRABLE NATIONAL PARK



Note: Agricultural production on the boundary of Bwindi Impenetrable National Park. Source: Alex Muhweezi

2.3 NON-CLIMATE STRESSORS ON BIODIVERSITY & ECOSYSTEM GOODS & SERVICES

Many factors other than climate change affect biodiversity and ecosystems goods and services. Uganda's biodiversity and its productivity are being adversely affected by: i) economic development such as infrastructure (e.g., road infrastructure development); ii) economic policy strategies (e.g., dependence on natural resources for economic growth); iii) extractive industries in biodiversity-rich areas (e.g., mining, oil and gas exploration in protected wildlife areas in Albertine Rift); iv) commercial and subsistence agricultural expansion into protected areas; and v) a rapidly growing population and resultant growth in demand for ecosystem goods and services.

These non-climate stressors interact with climate change to affect biodiversity and ecosystem goods and services in complex ways. Climate change stressors may sometimes induce non-climate change stressors. For example, changes in precipitation resulting in severe droughts trigger exploitation and agricultural expansion into forests (this is especially common in "non-gazetted" forests – forest habitats on privately owned land that are not legally protected) and wetlands (e.g., Pian-Upe-Opeta-Bisina wetlands complex in the Karamoja region), resulting in loss of the climate modulating benefits to biodiversity from the loss in forest canopy and water bodies. Agricultural encroachment is a major source of invasive plants species adversely affecting natural ecosystems (e.g., invasion of Sena species in tropical forests in Kyenjojo, Kyaka, and Kibale Districts in western Uganda). Agricultural expansion into forested areas is leading to forest fragmentation and disruption of biodiversity corridors (e.g., between Kasyoha-Kitomi and Maramagambo Central Forest Reserves along the escarpment of the Albertine Rift). This trend is reducing species capacity to migrate in response to climate change.

3.0 CURRENT ADAPATION INITIATIVES

Many initiatives in Uganda support biodiversity and management of ecosystem resources, and some of these initiatives focus on climate change. However, lack of enforcement of existing policies and regulations that prevent overuse of forest resources, agricultural encroachment, and human settlement in forests, as well as failure to protect wetlands, continue to impede the sustainable use of ecosystem resources in the Albertine Rift and Karamoja Regions.

3.1 POLICIES & STRATEGIES

Several national policies and strategies indirectly and directly focus on biodiversity and natural resources management in Uganda, including the National Action Plan of Adaptation (NAPA), the National Climate Change Policy, the Climate Change Policy Implementation Framework, and the soon-to-be-finalized National Biodiversity Strategy and Action Plan. Since 2009, Uganda has actively participated in Reducing Emissions from Deforestation and Forest Degradation+ (REDD+) processes with support from the Forest Carbon Partnership Facility and is preparing a National REDD+ Strategy. These policies and planning frameworks provide broad strategies and actions for addressing climate change in Uganda. Management plans (e.g., Park Management Plans, Forest Management Plans) for the 12 identified locations complement the frameworks. Overall, the strategies at policy and management levels tend to emphasize knowledge generation, capacity for designing and implementing mitigation and adaptation interventions, and building ecosystem resilience to the effects of climate change.

The following list presents some of the national policies and programs that directly or indirectly respond to climate change impacts on biodiversity and ecosystem resources in the 12 selected locations in the Albertine Rift and Karamoja regions.

1. **Climate Change Policy Coordination**: The government response to climate change is coordinated by the Climate Change Policy Committee that comprises representatives from ministries and government agencies responsible for economic and development planning, environment, agriculture, disaster preparedness, local government, energy, works and transport, health, and justice. The overall mandate of the committee is to provide policy-level guidance, coordination, harmonization, and integration of broader climate change policy initiatives and programs into national and sectoral plans, strategies, and actions, and to monitor their implementation.

2. **Institutional Strengthening:** The Climate Change Policy (approved in 2014) focused on strengthening institutional frameworks for management and coordination of climate change issues at both the national and district levels and across all sectors in partnership with non-state institutions such as nongovernmental organizations (NGOs) and civil society organizations. This strategy will provide training, institutional capacity strengthening, and upgrades to meteorology equipment and facilities for better prediction, analysis, and presentation of weather and climate-related information.

3. **Mainstreaming Climate Change in Macro-Economic and Sectoral Development Plans**: The Uganda Vision 2040 and National Development Plan (2009-2014) prioritize restoration of and

adding value to ecosystems (wetlands, forests, rangelands, and catchments), ensuring environmental sustainability, and mainstreaming issues of climate change into macroeconomic and sectoral development plans.

4. **National REDD+ Process**: Through the Ministry of Water and Environment, the government is coordinating the preparation of the Uganda REDD+ Strategy that will respond to the drivers of deforestation and forest degradation while promoting sustainable forest management and building carbon stocks. The REDD+ process has formulated guidelines for REDD+ demonstration plots, including within gazetted forest lands.

There is an active engagement between government and United Nations (UN) agencies (e.g., United Nations Development Programme [UNDP], United Nations Environment Programme [UNEP], and the Food and Agriculture Organization [FAO]) as well as several international environmental and advocacy NGOs (e.g., International Union for Conservation of Nature [IUCN], World Wildlife Fund [WWF], Oxfam) in promoting capacities and technologies for adaptation to climate change such as capacity building for national and local NGOs.

3.2 PROGRAMS IN THE SELECTED LOCATIONS

Managing agencies such as the Uganda Wildlife Authority and National Forest Authority are implementing location-specific programs that will assist with adaptation to impacts that are likely to occur more frequently as the climate changes. For example, under the UWA, Park General Management Plans for the Mgahinga, Bwindi, Queen Elizabeth, Murchison Falls, Kidepo, and Mt Rwenzori reserves provide strategies and actions for managing invasive plant species, fires, problem animals, tourism impacts on ecologically sensitive species and habitats, and management challenges. Similarly, the NFA implements Forest Management Plans for Echuya and Budongo Central Forest Reserves. These plans outline strategies and actions for managing habitat changes due to invasive species, pests, and diseases, as well as other eco-hydrological changes linked to climate change.

4.0 RECOMMENDATIONS

The following recommendations take into account existing policies and programs as well as the diverse biodiversity and ecosystem resources present in the Albertine Rift and Karamoja regions. Annex 2 provides additional recommendations for each location.

4.1 KNOWLEDGE GENERATION

These recommendations focus on building the knowledge base and data on climate change effects on biodiversity and ecosystem goods and services.

1. Improve climate monitoring in the Albertine Rift, establish long-term vegetation monitoring for quantification of climate change impact, and establish species response monitoring of sensitive vertebrate species.
2. Support the Uganda Wildlife Authority, the National Forestry Authority, the Wetlands Management Department, the National Environment Management Authority, the Fisheries Department, the Directorate of Water Resources Management, and the National Agricultural Research Organization to comprehensively assess resilience and vulnerability of ecosystems and keystone species in each location and to generate site-specific management actions.

4.2 STRENGTHENING CAPACITY TO DESIGN & IMPLEMENT ADAPTATION INTERVENTIONS

These recommendations focus on effective institutional responses to the effects of climate change by mandated national institutions and district-level authorities. These recommendations include building capacity of non-mandated institutions such as NGOs, which significantly contribute to the management of these locations.

1. Conduct an assessment of capacity needs of mandated institutions; develop and implement capacity building program based on this assessment.
2. Strengthen the capacity of the Uganda Wildlife Authority, the National Forestry Authority and Forestry Sector Support Department, and the Wetlands Management Department by reaffirming their mandate to strengthen ecological capacity to support resilience to climate change.
3. Provide training (e.g., Ecosystem-based Adaptation [EBA]), equipment/facilities, and logistics assistance to the Uganda Wildlife Authority, the National Forestry Authority, the Ministry of Water and Environment, the Ministry of Agriculture, Animal Industry and Fisheries, Districts, and communities for managing climate change related human-wildlife conflicts, floods, fires, and invasive species.
4. Support participation of civil society stakeholders and local communities that depend on ecosystem services in planning and implementing climate-resilient biodiversity management plans (i.e., forest management plans and national parks management plans).
5. Support integration of biodiversity conservation and management strategies and priorities within the climate change policy framework.

4.3 BUILD ECOSYSTEM-LEVEL RESILIENCE TO EFFECTS OF CLIMATE CHANGE

These recommendations focus on maintaining or enhancing ecosystem capacity to remain resilient to effects of climate change.

1. Establish and strengthen conservation corridors for endemic and threatened species in the Albertine Rift between protected areas based on existing research by the Wildlife Conservation Society and others.
2. Invest in EBA and strengthen people's traditional resource management strategies in the selected locations to help people adapt to climate change.
3. Improve management and enforcement of high altitude protected areas (e.g., in the Albertine Rift) to maintain their biological diversity.
4. Support the Uganda Wildlife Authority and the National Forest Authority to design and implement species vulnerability action plans for highly vulnerable species. Examples could include bamboo in Echuya, Mgahinga, and Bwindi as well as endemic species of Mt. Rwenzori, Kibale, and Kidepo.

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ANNEX 1. LOCATION SELECTION CRITERIA

The following matrix ranks the identified locations according to the assessment criteria.

KEY:

MGNP = Mgahinga Gorilla National Park; **ECFR** = Echuya Central Forest Reserve; **BINP** = Bwindi Impenetrable National Park; **RMNP** = Rwenzori Mountains National Park; **QENP** = Queen Elizabeth National Park; **KiNP** = Kibale National park; **SNP** = Semiliki National Park; **BFR** = Budongo Forest Reserve; **MFNP** = Murchison Falls National Park; **KNP** = Kidepo National park; **MKFR** = Mt. Kei Forest Reserve; **PUBO** = Pian-Upe-Bisina-Opeta

Scores range from 0 (little importance) to 5 (high importance) of each location for each characteristic.

TABLE A.1. LOCATION SELECTION CRITERIA

Characteristic	Location										
	MGNP	ECFR	BINPP	RMNP	QENP	KiNP	SNP	BFR	MFNP	KNP	MKFR
Habitat importance											
Forest condition	4	4	5	5	3	4	5	4	3	1	4
Aquatic/wetland condition	0	5	5	5	5	2	3	2	5	3	2
Biodiversity richness (endemicity)	3	3	5	5	3	5	5	4	4	5	5
Vulnerability											
Habitat for keystone species	5	4	5	4	3	5	5	5	4	5	4
Habitat for indigenous people	5	5	5	1	0	0	5	0	0	0	5
Vulnerability											
Effect of rise in temperature	3	3	3	5	4	3	3	3	3	3	3
Effect of unreliable rainfall or floods	3	3	3	3	5	3	3	3	3	3	3
Physical environment (altitude and slope)	4	4	4	4	3	3	2	2	2	3	2

Characteristic	Location										
Non-climatic stressors											
Agriculture pressure	5	5	5	3	3	4	3	3	2	2	2
Oil exploration and development pressures	0	0	0	0	3	0	2	2	5	2	0
Population pressures for ecosystem goods and services	5	5	5	3	3	5	3	3	2	2	2
Accessibility of ecosystem goods to markets	2	3	3	2	2	3	3	4	3	2	2
TOTAL	**39**	**44**	**48**	**40**	**37**	**37**	**42**	**35**	**36**	**31**	**34**

ANNEX 2. RECOMMENDATIONS BY LOCATION

TABLE A.2. RECOMMENDATIONS BY LOCATION

Location	Location	Characteristics/ecosystem products and services	Climate change impact/ sensitivity	Recommended action
Albertine Rift				
Mgahinga Gorilla National Park	Kisoro District	Afro-montane forest covering 4,750 ha (of which approximately 3,000 ha is forest) at an altitude range between 2,280 m and 4,127 m. Mgahinga borders Parc de Volcanoes and Virunga national park on the Rwanda and DRC portions of the Great Virunga Volcanoes. The park is home to mountain gorillas and 185 bird species. The key ecosystem goods and services are watershed values, tourism, and bamboo.	***Increased vulnerability of keystone species (mountain gorillas) and indigenous peoples (Batwa)***	*Undertake a comprehensive assessment of climate change effects and develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the Alpine forest ecosystem as well as mountain gorillas and Batwa forest dwellers; develop and implement Resilience and Vulnerability Plan of Action for the Mgahinga Gorilla National Park (MGNP).* *Train, equip, and provide logistics to MGNP Staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at MGNP in order to maintain ecosystem integrity and to address ecosystem and species responses to climate change.* *Integrate climate change response actions into overall Park Management Plan.*

Location	Location	Characteristics/ecosystem products and services	Climate change impact/ sensitivity	Recommended action
Echuya CFR	Kabale and Kisoro Districts	Echuya Forest Reserve encompasses 4,000 ha and includes a permanent high altitude swamp, Muchuya, which stands at 2,300 m in a narrow valley that is surrounded by steep forested hillsides. It is positioned at 01°17S, 29°49'E. Echuya is particularly known for its high quality bamboo, *Yushania alpina*. There are also areas of broad-leaved forest, particularly along the eastern side and the higher altitude northern end of the Kabale-Kisoro road. The forest cover is approximately 80-percent mature *Macaranga kilimandscharica* and *Hagenia abyssinica* forest and 20 percent mountain bamboo (*Yushania alpina)*. The forest contains the large alpine wetland Muchuya Swamp, which runs north-south along the reserve and drains to the southern boundary. Echuya Forest has high species diversity. Records show that the forest houses approximately 152 bird species, 54 butterflies, 43 moths, and 127 trees and shrubs, of which some enjoy global recognition as endangered species (e.g., Grauer's Swamp-warbler), or are near-threatened (e.g., Kivu Ground Thrush, Handsome Francolin, and Red–throated Alethe) among others. Approximately 40 percent of the butterflies are regional endemics. The key ecosystem goods and services are watershed values, tourism, and bamboo and indigenous people (Batwa).	***Increased vulnerability of keystone species (bamboo) and indigenous peoples (Batwa)***	*Undertake a comprehensive assessment of climate change effects; develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the Alpine forest ecosystem, bamboo, and Batwa forest dwellers; develop and implement Resilience and Vulnerability Plan of Action for the Forest reserve.* *Train, equip and provide logistics to MGNP Staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at ECFR in order to maintain ecosystem integrity as well as address ecosystem and bamboo responses to climate change.* *Integrate climate change response actions into overall Central Forest Reserve Management Plan.*

Bwindi Impenetrable National Park (BINP)	Kabale, Kanungu, and Kisoro Districts	A large primeval forest covering an area of 327,000 ha with altitudes spanning from 1,160 to 2,607 m above sea level. Recognized as a World Heritage Site for being the home of half the world's population of endangered mountain gorillas as well as being one of the most biologically diverse areas on earth. It is home to 120 species of mammals, 346 bird species, 310 butterfly species, 163 tree species, 104 fern species, and 27 frog species, as well as other many endangered species. Key ecosystem goods and services include water catchment protection, tourism, medicinal, and cultural values; it is also home to a population of indigenous forest pygmies (Batwa).	***Increased vulnerability of keystone species (mountain gorillas), indigenous people (Batwa), and endemic species***	*Undertake a comprehensive assessment of climate change effects; develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the montane forest ecosystem as well as mountain gorillas and Batwa forest dwellers; develop and implement Resilience and Vulnerability Plan of Action for BINP.* *Train, equip, and provide logistics to BINP staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at BINP in order to maintain ecosystem integrity as well as address ecosystem and species responses to climate change.* *Integrate climate change response actions into over-all BINP Management Plan.*
Mt. Rwenzori	Kasese and Bundibugyo Districts	Rwenzori Mountains National Park (RMNP) covers 55,000 ha. It stands at an altitude of 1,700 m to 5,110 m and is a protected national park. The park hosts 217 bird species, 17 restricted range species, some rare and spectacular bird species, 21 mammals, 14 butterflies, 199 trees/plants, 24 amphibians, and 100 species of fern. Key ecosystem goods and services include water catchment protection, tourism, and cultural values.	***Increased vulnerability of aquatic and protected species impacted by shrinking snow cover***	*Undertake a comprehensive assessment of climate change effects; develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the Alpine forest ecosystem and snow cap; develop and implement Resilience and Vulnerability Plan of Action for RMNP.* *Train, equip, and provide logistics to RMNP Staff to manage, invasive species, fires, etc.* *Strengthen management effectiveness at RMNP in order to maintain ecosystem integrity and to address ecosystem and species responses to climate change.* *Integrate climate change response actions into overall RMNP Management Plan.*

Queen Elizabeth National Park (QENP)	Rubirizi, Rukungiri, Kanungu, Kasese, and Kamwenge Districts	Largely savanna covering 223,000 ha, of which approximately 40,000 ha is forest at an altitude ranging from 910m to 1,365 m. The national park also overlaps with Maramagambo Central Forest Reserve and the Lake George Ramsar Site. The park is a Man and Biosphere Reserve with a unique combination of grasslands, woodlands, moist tropical forests, wetlands, and open water bodies/lakes. The park houses 610 bird species, 97 mammals, 288 trees/plants, and 54 reptiles. The key ecosystem service is tourism.	***Increased vulnerability to prevalence of invasive species (e.g., Congress weed)***	*Undertake a comprehensive assessment of climate change effects; develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the savannah, wetlands, and aquatic and forest ecosystems in the park; develop and implement Resilience and Vulnerability Plan of Action for QENP.* *Train, equip, and provide logistics to QENP Staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at QENP in order to maintain ecosystem integrity as well as address ecosystem and species responses to climate change.* *Integrate climate change response actions into overall Park Management Plan.*
Kibale Forest/Kibale National Park (KNP)	Kamwenge, Kabarole, and Kyenjojo Districts	Forest covering 560,000 ha with the highest diversity and density of primates in Africa (totaling 13 species), 60 mammal species, 339 species of birds, 229 tree species, and 250 butterflies. Kibale forest is close to a site of Pleistocene refugia and serves as the eastern limit of Congolean species. Key ecosystem goods and services include water catchment protection, tourism, and medicinal and cultural values.	***Increased vulnerability of endemic species***	*Undertake a comprehensive assessment of climate change effects; develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the forest ecosystem, endemic species, and watershed; develop and implement Resilience and Vulnerability Plan of Action for KNP.* *Train, equip, and provide logistics to KNP Staff to manage human-wildlife conflicts, invasive species, and fires.* *Strengthen management effectiveness at KNP in order to maintain ecosystem integrity and to address ecosystem and species responses to climate change.* *Integrate climate change response actions into overall Park Management Plan.*

Semliki National Park (SNP)	Bundibugyo District	Tropical forest covering 21,900 ha (of which approximately 19,500 ha is forest) at an altitude ranging between 670 m and 760 m. The entire national park lies in the Albertine Rift bordering Virunga National Park in the DRC and North Rwenzori Forest Reserve in Uganda. The forest is cut off from the rest of East Africa by the Rwenzori mountains and represents an easterly extension of the great Ituri forests; its flora and fauna show strong affinity with the Congo basin forests. The forest houses 131 of the 144 Guinea-Congo forest biome species (including 31 of the 70 species only found in Semliki), eight species of diurnal primates, and 51 species of butterflies. The main ecosystem goods and services are water, tourism, and provision of home to indigenous forest dwellers (the Batwa).	***Increased vulnerability of endemic species and indigenous forest people (Batwa)***	*Undertake a comprehensive assessment of climate change effects; develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the forest ecosystem, endemic species, and Batwa forest dwellers; develop and implement Resilience and Vulnerability Plan of Action for SNP.* *Train, equip, and provide logistics to SNP Staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at SNP in order to maintain ecosystem integrity and to address ecosystem and species responses to climate change.* *Integrate climate change response actions into overall Park Management Plan.*
Budongo Central Forest Reserve (BCFR)	Masindi, Hoima, and Buliisa Districts	Budongo Central Forest Reserve covers 79,300 ha, lies at 31°35'E, 01°45'N, and is located in Masindi district. It stands at an altitude of 700 m to 1,270 m. It is a protected area and one of the important bird areas in Uganda. Two species of birds (Yellow-footed Flycatcher and Puvel's illadopsis) found in Budongo are not found anywhere else in East Africa. It is the second-most important forest for the Guinea-Congo species after Semliki, and hosts many other rare species. Conservation issues affecting the reserve and posing future threats to the birds include illegal pit sawing, poaching, and commercial sugar farming. Key ecological serves and goods include watershed values, timber, and tourism.	***Increased sensitivity to non-climate stressor (agriculture)***	*Undertake a comprehensive assessment of climate change effects and develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the forest ecosystem; develop and implement Resilience and Vulnerability Plan of Action for BCFR.* *Train, equip, and provide logistics to BCFR Staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at BCFR in order to maintain ecosystem integrity as well as address ecosystem and species responses to climate change.* *Integrate climate change response actions into over-all Forest Management Plan*

Murchison Falls National Park (MFNP)	Masindi, Hoima, Buliisa, Kiryan-dongo, Nwoya, and Amuru Districts	A combination of grasslands, wooded savannah, tropical forests, wetlands, and open water covering approximately 39,000 ha at an altitude of more than 600 m. The park houses 109 species of mammals, 476 bird species, and 145 trees/plants. The key ecosystem services are water, tourism, and cultural values.	***Increased sensitivity to non-climate stressor (oil)***	*Undertake a comprehensive assessment of climate change effects; develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the forest, savannah, and aquatic and wetlands ecosystem; develop and implement Resilience and Vulnerability Plan of Action for MFNP* *Train, equip, and provide logistics to MFNP Staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at MFNP in order to maintain ecosystem integrity and to address ecosystem and species responses to climate change.* *Integrate climate change response actions into over-all Park Management Plan.*
Karamoja Region				
Kidepo Valley National Park (KVNP)	Kotido District	A semi-arid plan interspersed with hills, rocky outcrops, and mountain ranges covering 144,200 ha (of which 2,000 ha is forest) at an altitude ranging between 1,220 m-2,750 m. The park houses 472 species of birds, 86 species of mammals of which 28 (including Cheetah) are not found in any other parks in Uganda, 192 trees, 465 bird species. Ecosystem goods and services include watershed values, tourism and traditional grazing ground for the pastoralist Karamajong people.	***Increased vulnerability of keystone species (e.g., cheetah)***	*Undertake a comprehensive assessment of climate change effects and develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the savannah ecosystem and keys stone species and develop and implement Resilience and Vulnerability Plan of Action for KVNP.* *Train and equip and provide logistics to KVNP Staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at KVNP in order to maintain ecosystem integrity as well as address ecosystem and species responses to climate change* *Integrate climate change response actions into over-all Park Management Plan*

Pian-Upe-Opeta/ Bisina (PUBO) Complex	Nakapirip-iriti, Amuria, Sironko Districts	The PUBO wetlands complex in Northeastern Uganda is an extensive flat grassland, floodplain grassland, and swamp system draining Mount Elgon and South Karamoja into Lake Kyoga. Lake Opeta is 56,600 ha, lies at 34°10'E, 01°40'N, and is shared by Katakwi, Kumi, Mbale, and Soroti Districts. It stands at an altitude of 1,030 m and is an unprotected area. Lake Opeta and its surrounding swamp is the only significant wetland in the Karamoja area. It is one of the remaining few intact marshes in Uganda and the only permanent wetland in Karamoja area. The area is important for pastoralism (it hosts up to 20,000 head of cattle in dry season). Lake Bisina is 6100 ha and lies at 33°51'E, 1°42'N in Kumi District. It stands at an altitude of 1,030 m and is an unprotected area. The Fox's Weaver — the only endemic bird species in Uganda — is found in this area and appears to be common in the vicinity of water during the breeding season. The status of the species is not well established, but its distribution seems to be restricted to the northern part of the country. Seven Lake Victoria biome species are recorded, including the papyrus Gonolek and the Northern Brown-throated Weaver, which breeds in the short fringing papyrus. Key ecological goods and services include provision of freshwater of good quality and quantity into international waters (through Lake Kyoga into the Nile System), seasonal grazing, fisheries, and cropland.	***Increased vulnerability to extreme wet (floods) or extreme dry conditions***	*Undertake a comprehensive assessment of climate change effects; develop and implement Plan of Action to address impacts of climate change.* *Undertake a comprehensive assessment of resilience and vulnerability of the wetlands and aquatic ecosystems, and develop and implement Resilience and Vulnerability Plan of Action for PUBO complex.* *Train and equip and provide logistics to Pian Upe Wildlife Reserve (PUWR) staff to manage human-wildlife conflicts, invasive species, fires, etc.* *Strengthen management effectiveness at PUWR to maintain ecosystem integrity and to address ecosystem and species responses to climate change.* *Integrate climate change response actions into overall Wetland Management Plan.*

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